National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594

WPR20LA283

AIRWORTHINESS

Group Chair's Factual Report

February 8, 2023

A. ACCIDENT

Location: Pine Grove, Oregon
Date: August 24, 2020
Time: 18:00 Pacific daylight time
Helicopter: Kaman K-1200, registration N314

B. AIRWORTHINESS GROUP

Group Chair	Chihoon Shin National Transportation Safety Board Washington, DC
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C. SUMMARY

On August 24, 2020, about 1800 Pacific daylight time, a Kaman K-1200 helicopter, N314, was substantially damaged when it was involved in an accident near Pine Grove, Oregon. The pilot was fatally injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 133 external load flight.

The accident helicopter, owned and operated by Central Copters, was performing a firefighting flight and had an external load composed of a long line and a water bucket. The helicopter impacted a shallow river in an area surrounded by wooded terrain.

D. DETAILS OF THE INVESTIGATION

1.0 Helicopter Information

1.1 Helicopter Description

The Kaman K-1200, also known as the K-MAX, is type certificated under Federal Aviation Administration (FAA) type certificate data sheet (TCDS) No. TR7BO as a Normal Category rotorcraft. The helicopter is equipped with a single Honeywell T5317A-1 turboshaft engine[1] mounted behind the transmission and rotor systems. The helicopter airframe is composed of a single-seat cockpit, main fuselage, tail boom with a vertical fin and horizontal stabilizer, and a tricycle landing gear. The tailboom contains a moveable left and right horizontal stabilizer, with end plates, as well as a vertical fin.

The K-1200 helicopter has two counterrotating, side-by-side, intermeshing rotors, with two blades per rotor for a total of four blades. The rotors are out of phase by 90° and are tilted outward to allow each blade to clear its opposing rotor hub. The two rotor systems are mounted to, and driven by, a common transmission. When viewed from above, the left rotor system turns counterclockwise and the right system turns clockwise. The rotor blade spar is manufactured from laminated spruce planks, the afterbody is manufactured from a honeycomb core material, and the blade is covered by a fiberglass composite skin. The two blades for each rotor system are composed of a matched set, balanced at the factory, with the set having an "A" blade (colored white at the tip) and a "B" blade (colored red at the tip). The single-seat cockpit flight control system is composed of a standard cyclic, collective, and pedal controls setup. Each rotor head has a central teetering hinge for blade flapping. Furthermore, each rotor head has a lead-lag hinge with two lead-lag dampers, one on the advancing and one of the trailing sides of each blade.

1.2 Rotor Blade Servo Flap Design

The K-1200 rotor system utilizes servo-flaps to control rotor blade pitch changes. The Kaman K-1200 Maintenance and Servicing Instructions (KMM) provides a description of this novel design approach:

A servo-flap is mounted on each blade near the 3/4 radius and is controlled by [control] rods which transfer conventional cockpit flight control inputs through the azimuth assemblies to each servo flap. The servo-flap controls the pitch of the rotor blade and acts as an aerodynamic stabilizer. Because the servo-flap uses energy drawn from the air stream to twist the blade, control faces need only be high enough to deflect the small servo-flap. The control system operating loads are relatively light

[1] On May 6, 2022, the type certificate for the T53 engine, under TCDS No. E17EA, was transferred from Honeywell to Ozark Aeroworks.

resulting from the low aerodynamic forces on the flaps compared to blade aerodynamic forces. This eliminates the need for hydraulic boost and artificial stability augmentation systems.

Rotor blade pitch changes are accomplished through the servo-flaps. Aerodynamic action of the servo flap changes blade pitch by twisting the blades. Blade pitch is controlled by the collective stick, the cyclic stick, and the directional pedals, all of which are connected to the servo-flaps by direct mechanical linkage.

Each servo flap is located behind the rotor blade trailing edge between rotor stations (RSTA) 190 and 226. [2]

1.3 Accident Helicopter History

The accident helicopter, operated by Central Copters, was serial number (S/N) A94-0032 and the engine was S/N LE-LYC1. At the time of the accident, the helicopter had an aircraft total time (ATT) of about 5,187.3 hours.

The left rotor system had blade S/N 473A ('white') and S/N 473B ('red') installed.[3] Blade S/N 473A had servo flap S/N 0529A installed and blade S/N 473B had servo flap S/N 0536A installed.

The right rotor system had blade S/N 470A ('white') and S/N 470B ('red') installed. Blade S/N 470A had servo flap S/N 0564A installed and blade S/N 470B had servo flap S/N 0565A installed.

On August 2, 2016, all four rotor blades were installed on the accident helicopter with a component total time (CTT) of 0 hours and at an ATT of 4,190.5 hours. At the time of the accident, all four rotor blades had a CTT of 996.8 hours.

2.0 Accident Site and Wreckage Observations

2.1 Background

At the time of the accident, the National Transportation Safety Board (NTSB) did not travel to the accident site due to restrictions from the Coronavirus disease 2019 (COVID-19) pandemic. At the request of the NTSB, photographs and documentation of the accident site was conducted by the operator. On September 2, 2020, the wreckage was recovered to a hangar in Prineville, Oregon (OR). On September 21, 2020, representatives from the NTSB, Central Copters, and Kaman

[2] All RSTA values are in inches. The rotor system's center of rotation (rotational axis) is RSTA 0 and the tip end of the blade is at RSTA 289.00.

[3] On the K-1200, the rotor blade S/N ending with an "A" is identified as the 'white' blade while the rotor blade S/N ending with a "B" is identified as the 'red' blade.

Aerospace conducted an initial examination of the wreckage in Prineville, OR, with virtual participation by representatives from the Federal Aviation Administration (FAA), NTSB, and Honeywell. The servo flap from left rotor blade S/N 473A was shipped to the NTSB Materials Laboratory in Washington, District of Columbia (DC) for further examination. On October 7, 2020, representatives from Central Copters and Kaman Aerospace conducted an aerial survey of the trees surrounding the accident site to search for evidence of rotor strikes and to search for additional wreckage; the tip end of left rotor blade S/N 473B was recovered.

On February 12, 2021, representatives from the NTSB, Central Copters, Kaman Aerospace, and Honeywell examined the wreckage in Prineville, OR; representatives from the FAA and NTSB also participated virtually for this examination. On March 16, 2021, representatives from the NTSB, Central Copters, and Kaman Aerospace convened at Prineville, OR to retrieve the servo flap from the remaining three rotor blades and to remove the engine from the wreckage for shipment to Honeywell in Phoenix, Arizona (AZ) for further examination. On April 28, 2021, the engine was examined at Honeywell facilities in Phoenix, AZ under oversight of the NTSB. On June 1-2, 2022, representatives from the NTSB, the Transportation Safety Board of Canada (TSB Canada), Central Copters, and Kaman Aerospace revisited the wreckage in Prineville, OR for comparative analysis to another K-1200 accident (registration C-FZVM) that occurred on October 4, 2021 in British Columbia, Canada.[4]

The NTSB Vehicle Recorders Division recovered data from a global positioning system (GPS) flight tracking device, a Latitude Technologies SkyNode S100, that was installed on the accident helicopter.[5] The recovered data showed that shortly before the accident, the helicopter was descending and began to slow down. The last data point was about 138 feet above ground level at 0 knots and was about 15 feet away from the location of the main wreckage. **Appendix A** contains images derived from the recovered GPS device and the approximate location of the main wreckage and rotor blades.

2.2 Structures

The entirety of the airframe was found at the accident site and there was no evidence of an inflight fuselage breakup (**Figure 1**). The helicopter came to rest on its right side (**Figure 2**). The nose of the helicopter had crushed aft and inward. The tail boom exhibited deformation on its underside immediately aft of the horizontal stabilizer resulting in the aft portion of the tail boom being bent downward. The main and nose landing gears remained installed. The left horizontal stabilizer remained installed, and the right horizontal stabilizer had fractured and separated but was

[4] For additional details of the accident involving C-FZVM, refer to TSB Canada air transportation safety investigation No. A21P0107.

[5] For additional details of the GPS device data recovery, see the Global Positioning System Devices – Specialist's Factual Report in the docket for this investigation.

found next to its normally installed position. The vertical fin remained installed but its top end was impact damaged.

The long line remained attached to the hook of the helicopter and had wrapped around the fuselage. The direction of the long line wrapping around the fuselage was consistent with the fuselage rolling to the left around the long line or conversely the long line wrapping above and to the right of the fuselage. There was no evidence of contact between the rotor systems and either the long line or the water bucket. The water bucket remained attached to the end of the long line and was found about 40 feet upstream of the accident site resting upright in the water and half-filled with silt from the river. Examination of the hook found no anomalies. The hook was able to be opened using the manual release.

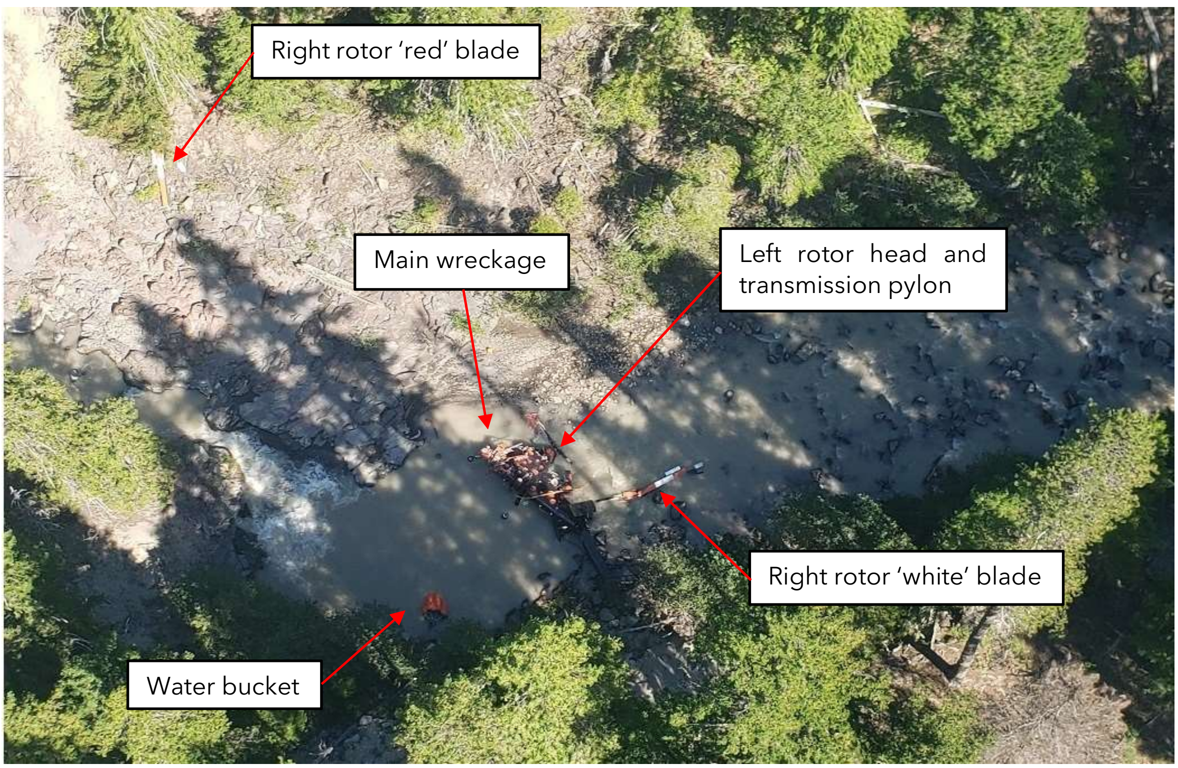

Figure 1. An aerial view of the accident site. (Image provided by Central Copters and edited by the NTSB.)

Figure 2. The fuselage at the accident site. (Image provided by Central Copters.)

2.3 Rotor System

2.3.1 Rotor Drive System

The main transmission remained installed on the airframe. The forward end of the [input] Kaflex driveshaft remained installed on the main transmission but was fractured at the flex plates. Both left and right transmission pylons had separated from the main transmission center housing (**Figure 3**). The left transmission pylon had separated at pylon housing's interface to its ring gear, with the ring gear and a portion of the pylon housing flange still attached to the center housing, and the pylon was retained to the transmission by one of the two control rods. The right transmission pylon had also separated at the pylon housing's interface to its ring gear, but the ring gear remained attached to the separated pylon housing. Several planetary gears and their bearings were found near the accident site. The left and right sun gears remained installed but exhibited damage to their gear teeth primarily to the top side of their gear teeth. On the left ring gear, gear teeth impressions were seen on the adjacent housing in two distinct regions. The first region was an arc from 8 o'clock to the 11 o'clock location when looking down at the ring gear from above (**Figure 4**). The second region was an arc from 1 o'clock to the 4 o'clock location. Similar gear impressions were not observed on the lower housing adjacent to the right ring gear but a portion of that lower housing was fractured from 2 o'clock to 4 o'clock location; that portion of the lower housing remained attached to the right transmission pylon.

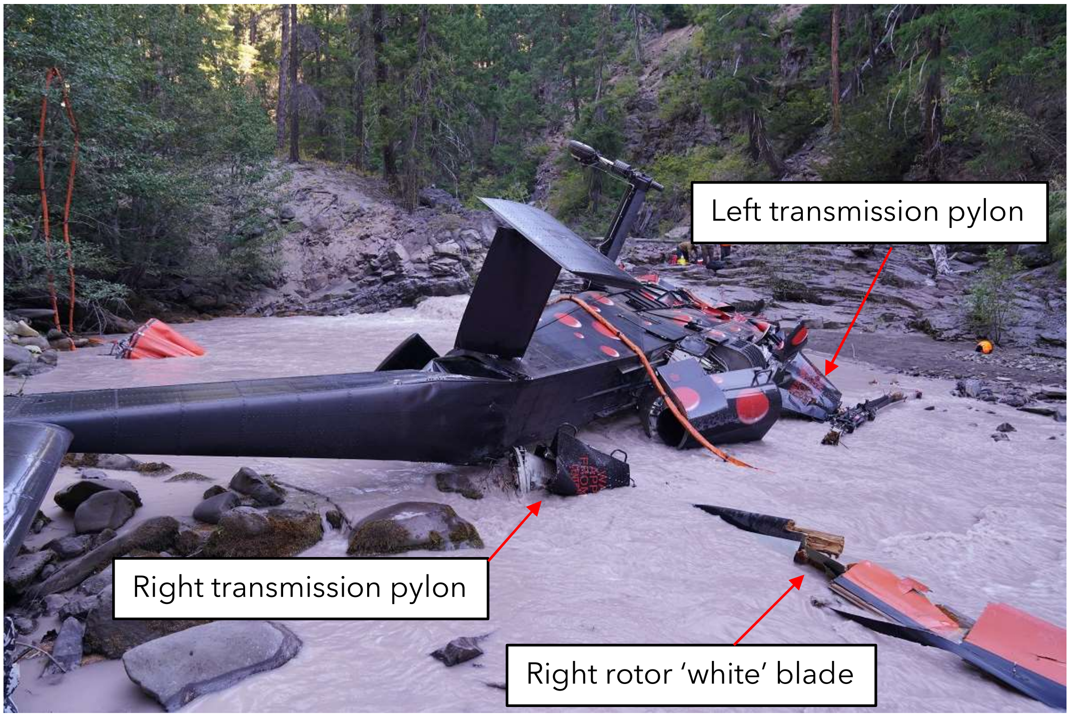

Figure 3. The separated transmission pylons at the accident site. (Image provided by Central Copters.)

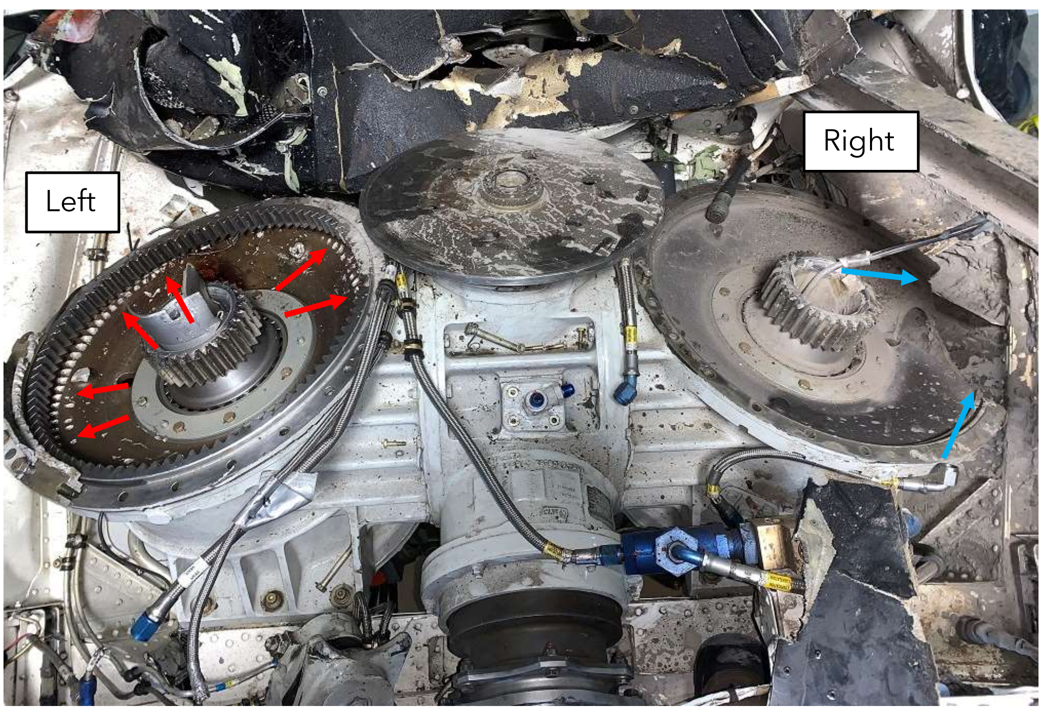

Figure 4. The main transmission center housing with the left and right sun gears. Aircraft forward is to the top of this image. The red arrows show the arcs of gear teeth impressions and the blue arrows show the fractures on the lower housing.

The right transmission pylon housing exhibited deformation on its forward side such that the housing was bent forward (**Figure 5**). The aft side of the attachment flange, attaching the conical housing to the ring gear and the right-side lower housing, was bent upward and had partially lifted off. The right-side planetary carrier remained installed within the right transmission pylon and attached to its rotor shaft, but none of its five planetary gears were present. Three of the five planetary gear bearings remained installed on the planetary carrier while two of the five bearings were not present. The rotor shaft remained connected to the right rotor head via the teetering bolt. The center strap fitting, normally installed between the upper ends of the left and right transmission pylons, remained attached to the right transmission pylon but was fractured and separated from the left transmission pylon (**Figure 6**).

The left transmission pylon housing exhibited minor deformation on its aft side. A small portion of the center strap fitting remained attached to the left transmission pylon (**Figure 7**). The right side of the conical housing had two parallel vertical cracks that extended about two-thirds of the height of the housing (**Figure 8**). The housing material between these two cracks had bulged outward near its upper side. The left-side planetary carrier remained installed within the left transmission pylon and attached to its rotor shaft. Four of the five planetary gears remained installed on the carrier, with the fifth planetary gear and its bearing separated from the carrier. The rotor shaft remained connected to the left rotor head via the teetering bolt.

Figure 5. The right transmission pylon showing deformation of the housing.

Figure 6. The right transmission pylon and center strap fitting (red arrow).

Figure 7. The left transmission pylon and center strap fitting (red arrows).

Figure 8. The left transmission pylon and rotor head. The two cracks extending vertically up the housing are identified with red arrows.

2.3.2 Left Rotor System

The 'white' blade (S/N 473A) had fractured and separated in the vicinity of three RSTA locations: RSTA 77, RSTA 232, and RSTA 260. The majority of the 'white' blade pieces was found grouped together about 560 feet away from the main wreckage in a wooded area (**Figure 9**). The tip section of the 'white' blade exhibited fragmentation and its leading edge exhibited significant deformation in multiple locations (**Figure 10**). The servo flap spar remained installed on the 'white' blade but the servo flap afterbody had completely fractured and separated from the spar and was found about 192 feet away from the main wreckage (**Figure 11**). Both the upper and lower fractures of the servo flap afterbody were nearly straight in the spanwise direction. The servo flap inboard bracket exhibited a large area of contact damage on its outboard side as well as evidence of contact with the chordwise servo flap control rod bolt head (**Figure 12**). The servo flap outboard bracket was undamaged. The inboard section of the 'white' blade remained attached to its rotor head grip. The leading edge of the inboard section (still attached to the rotor head grip) exhibited impact marks and spanwise fragmentation along the spar (**Figures 13 and 14**).

Figure 9. The left rotor 'white' blade as found about 560 feet away from the main wreckage. The red bracket identifies the servo flap spar that remained attached. (Image provided by Central Copters.)

Figure 10. The reconstructed tip section of the left rotor 'white' blade is seen in the red box, with the reconstructed tip section of the 'red' blade seen above.

Figure 11. The separated servo flap afterbody found about 192 feet away from the main wreckage. (Image provided by Central Copters.)

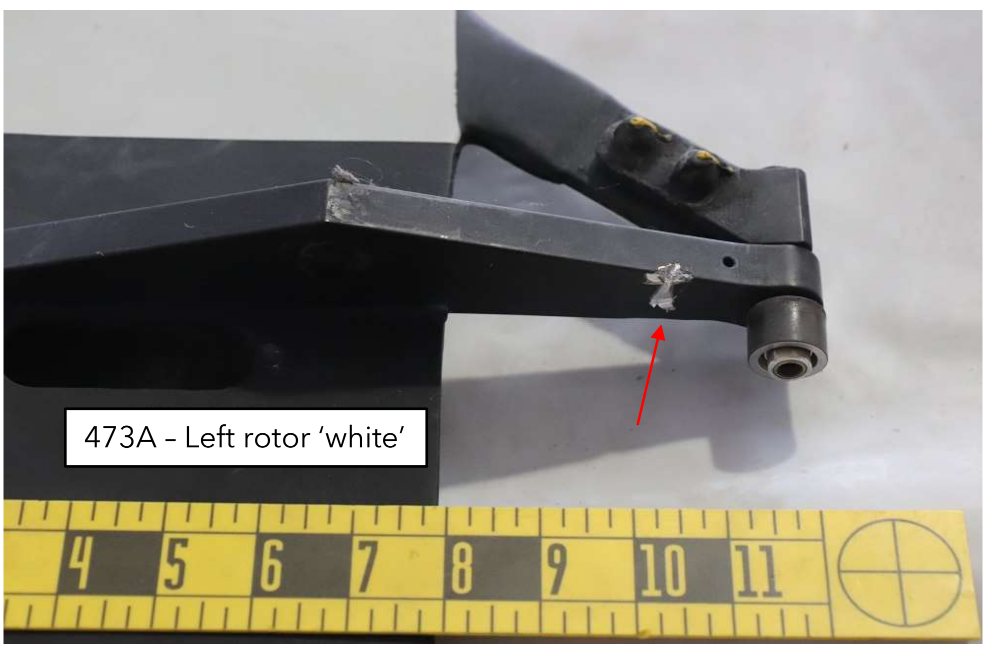

Figure 12. Contact damage (red arrow) observed on the outboard side of the inboard servo flap bracket of the left rotor 'white' blade.

Figure 13. The lower surface of the inboard section of the left rotor 'white' blade.

Figure 14. The upper surface of the inboard section of the left rotor 'white' blade.

The 'red' blade (S/N 473B) had fractured and separated in the vicinity of two RSTA locations: RSTA 48 and RSTA 245. The bulk of the 'red' blade was found about 500 feet away from the main wreckage, with the tip section found about 570 feet away in a wooded area (**Figure 15**). On the tip section of the 'red' blade, the tip cap and a portion of the afterbody had separated. On the inboard side of the RSTA 245 fracture, the leading edge abrasion strip and weight exhibited deformation in the direction opposite of normal rotation. The servo flap was whole and remained installed on the 'red' blade. The servo flap inboard bracket exhibited an area of moderate contact damage on its outboard side as well as evidence of contact with the chordwise servo flap control rod bolt head (**Figure 16**). The servo flap outboard bracket was undamaged. On the underside of the blade, between the blade fracture at RSTA 48 and RSTA 83.5, a dark colored contact mark, similar in color to the leading edge coating of the rotor blades, as well as impacted spar, core, and skin, were observed (**Figure 17**). At the inboard side of the fracture at RSTA 48, the lower trailing edge corner exhibited a blunted impact mark (**Figure 18**). The inboard section of the blade remained attached to its rotor head grip.

Figure 15. The left rotor 'red' blade as found about 570 feet away from the main wreckage. (Image provided by Central Copters.)

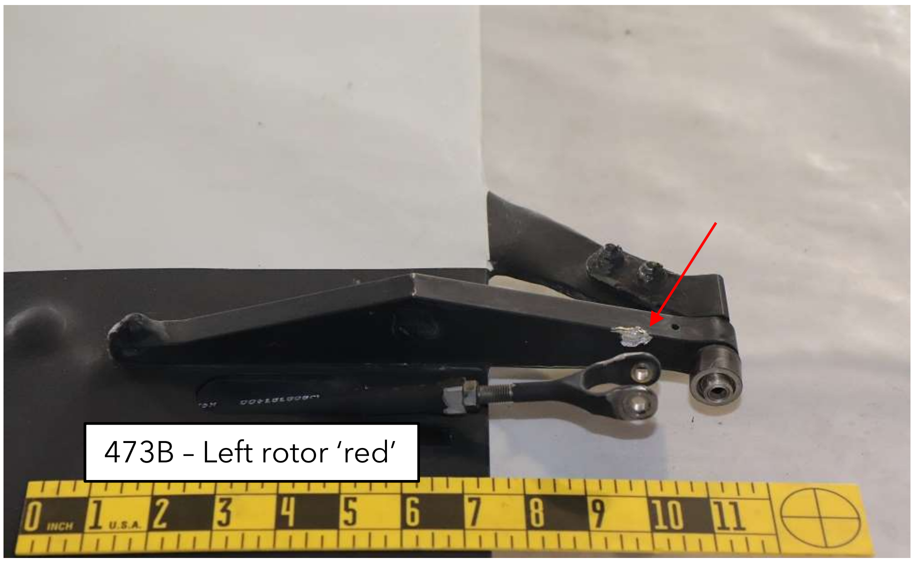

Figure 16. Contact damage (red arrow) observed on the outboard side of the inboard servo flap bracket of the left rotor 'red' blade.

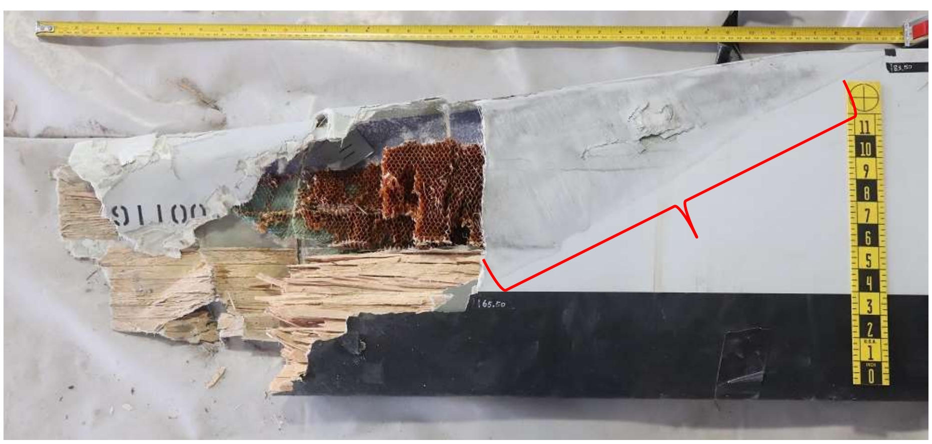

Figure 17. The inboard fracture of the left rotor 'red' blade with the skin exhibiting an area of contact, identified by the red bracket, that is dark in color.

Figure 18. The inboard section of the left rotor 'red' blade. The red arrow points to the blunted impact mark.

For the blade lead-lag damper between the leading (advancing) side of the 'red' blade and the lagging (trailing) side of the 'white' blade, only the damper piston was present and the damper housing was not recovered. The damper piston and its rod end remained attached to the 'red' blade leading side damper attachment horn (**Figure 19**). The damper piston did not exhibit significant bending deformation. The damper housing's rod end remained installed on the 'white' blade lagging side damper attachment horn. The two damper attachment horns did not exhibit significant deformation.

On the opposite side of the rotor head, the blade lead-lag damper was found about 86 feet away from the main wreckage. The rod ends of both damper piston and housing remained attached to the 'white' blade leading side damper horn and the 'red' blade lagging side damper horn, respectively. The damper piston-side attachment horn did not exhibit significant deformation. The damper housing-side attachment horn exhibited a slight downward deformation.

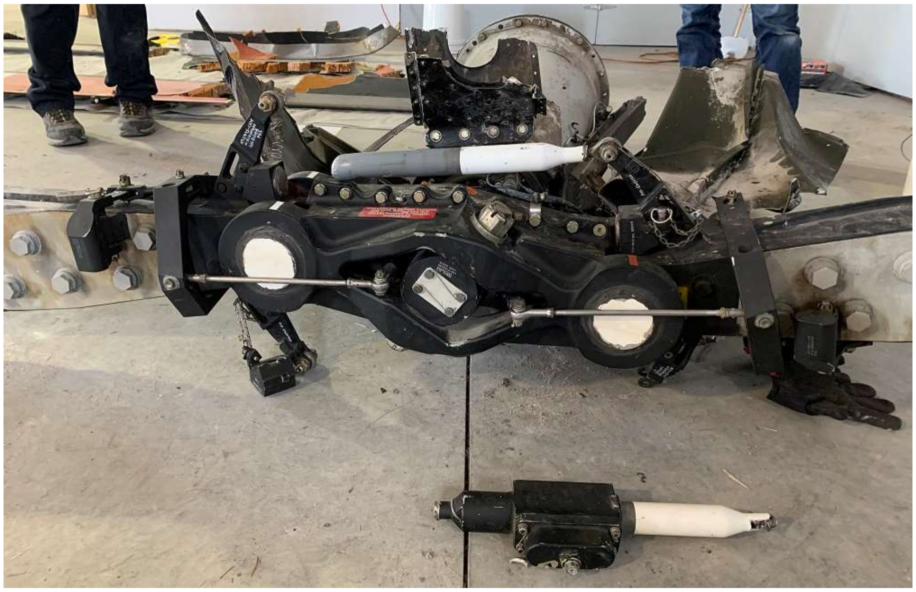

Figure 19. The lead-lag damper remnants for the left rotor system.

The lead stop remained installed on the ‘red’ blade leading side damper attachment horn, but the lag stop had fractured separated from the ‘red’ blade lagging side damper attachment horn and was not recovered. The lead stop had fractured and separated from the ‘white’ blade leading side damper attachment horn but was remained with the rotor head assembly via a pin and metal chain. The lag stop remained installed on the ‘white’ blade lagging side damper attachment horn.

The rotor head and rotor shaft remained installed. The left transmission pylon forward and aft struts remained attached at their upper ends and did not exhibit significant deformation. The bolt at the lower end of the forward strut remained installed its clevis. A fractured remnant piece of the forward airframe strut mount lug was retained in the lower clevis of the forward strut. The attachment bolt remained installed within the lower clevis of the forward strut. The aft airframe strut mount was present on the airframe but the horizontal portion of the aft mount was fractured and partially separated from the airframe. The upper portion of the attachment lug also had fractured in overload.

The servo flaps and their control rods from both ‘red’ and ‘white’ blades were examined in the NTSB Materials Laboratory in Washington, DC. The details of this examination can be found in NTSB Materials Laboratory Report in the docket for this investigation.

2.3.3 Right Rotor System

The ‘white’ blade (S/N 470A) remained attached to the right rotor head but had fractured and partially separated in the vicinity of four RSTA locations: RSTA 83, RSTA 118, RSTA 183, and RSTA 233. The bulk of the 'white' blade was found adjacent to the main wreckage near the tail boom (**Figures 20 and 21**). The after body of the tip end of the 'white' blade was found about 180 feet downstream from the main wreckage. The servo flap was whole and remained installed on the 'white' blade. The servo flap inboard bracket exhibited a small area of contact damage on its outboard side as well as evidence of contact with the chordwise servo flap control rod bolt head (**Figure 22**). The servo flap outboard bracket was undamaged. The inboard section of the 'white' blade remained attached to its rotor head grip (**Figure 23**). The 'white' blade was separated from its hub to facilitate its recovery.

Figure 20. The right rotor 'white' blade at the accident site. (Image provided by Central Copters.)

Figure 21. The recovered right rotor 'white' blade.

Figure 22. Contact damage (red arrow) observed on the outboard side of the inboard servo flap bracket of the right rotor 'white' blade.

Figure 23. The inboard section of the right rotor 'white' blade.

The 'red' blade (S/N 470B) had fractured and separated in the vicinity of RSTA 94. The bulk of the 'red' blade was found about 81 feet away from the main wreckage (**Figure 24**). The servo flap was whole and remained installed on the 'red' blade. The servo flap inboard bracket exhibited a small area of contact damage on its outboard side as well as evidence of contact with the chordwise servo flap control rod bolt head (**Figure 25**). The servo flap outboard bracket was undamaged. The inboard section of the 'red' blade remained attached to its rotor head grip (**Figure 26**).

Figure 24. The right rotor 'red' blade about 81 ft away from the main wreckage. (Image provided by Central Copters.)

Figure 25. Contact damage (red arrow) observed on the outboard side of the inboard servo flap bracket of the right rotor 'red' blade.

Figure 26. The inboard section of the right rotor ‘white’ blade.

Both blade dampers had fractured and separated, and neither damper was found and recovered (**Figure 27**). For the damper between the ‘white’ blade leading side and ‘red’ blade lagging side, both rod ends remained attached to their respective damper attachment horns. The ‘white’ blade leading side damper attachment horn did not exhibit significant deformation. The ‘red’ blade lagging side damper attachment horn had deformed downward.

Figure 27. The right rotor head with neither damper present.

For the damper between the 'red' blade leading side and the 'white' blade lagging side, both rod ends remained attached to their respective damper attachment horns, but the rod end attached to the 'white' blade lagging side was fractured in overload at its threads. The 'red' blade leading side damper attachment horn had bent upward. The 'white' blade lagging side damper attachment horn did not exhibit significant deformation. Both the lead stop and lag stop remained installed on both the 'red' and 'white' blades. Both the 'red' and 'white' blade lag stops exhibited transferred material on its contact surface.

The rotor head and rotor shaft remained installed. The right transmission pylon forward strut remained installed on the airframe but was fractured below the clevis on its upper end. The forward and aft strut upper clevises remained attached to the right transmission pylon. However, the majority of the aft strut was not found. The aft airframe strut mount remained installed on the airframe and the upper portion of its attachment lug had fractured in overload.

The servo flaps and their control rods from both 'red' and 'white' blades were examined in the NTSB Materials Laboratory in Washington, DC. The details of this examination can be found in NTSB Materials Laboratory Report in the docket for this investigation.

2.4 Flight Control System

The cyclic control, collective control, and pedals were present in the cockpit. The control tubes and bellcranks from the cockpit controls to the azimuth control installation exhibited impact fractures but no evidence of disconnection. The left and right azimuth controls remained installed on the lower side of the main transmission.

The two azimuth control rods for the right rotor system were fractured in overload. One control rod extended up through the sun gear before it fractured. The second control rod was fractured just below the upper surface of the sun gear, with the remainder of this control rod extending out of the bottom of rotor shaft in the right transmission pylon. The azimuth control rods were connected at their upper ends to their respective hub-to-blade control rods, which in turn remained connected to the U-cranks located at the root of each rotor blade. The 'red' blade hub-to-blade control rod was slightly bent at the rod's threaded connection to its rod end, with the bend being in the direction opposite of rotor rotation. At the inboard end of each rotor blade, the idler remained connected to the U-crank and to the inboard clevis of the spanwise servo flap control rod within the blade. For each rotor blade, the servo flap control rod was fractured and deformed at the inboard locations where the rotor blades had fractured. At each servo flap bell crank, within the blade near the inboard servo flap bracket, the spanwise servo flap control rod was connected to the bellcrank. Each chordwise servo flap control rod remained connected between the bellcrank and their respective servo flap control horn.

For the left rotor system, one azimuth control rod had fractured just below the upper surface of the sun gear. The remainder of this azimuth control rod was present within the rotor shaft of the left transmission pylon. The second azimuth control rod was continuous between the left transmission pylon and the main transmission center housing and was cut to facilitate recovery of the wreckage. Both azimuth control rods were connected at their upper ends to their respective hub-to-blade control rods, which in turn remained connected to their U-cranks. At the inboard end of each rotor blade, the idler remained connected to the U-crank and to the inboard clevis of the spanwise servo flap control rod within the blade. For each rotor blade, the servo flap control rod was fractured and deformed at the inboard locations where the rotor blades had fractured. Each chordwise servo flap control rod remained connected between the bellcrank and their respective servo flap control horn.

2.5 Powerplant

2.5.1 Initial Examination

The engine remained installed on the airframe via the engine mounts. The inlet guide vanes and first stage compressor blades exhibit evidence of foreign object debris (FOD) ingestion. The tip ends of the first stage compressor blades exhibited bending in the direction opposite of normal rotation. Evidence of metal spray was observed on the second stage power turbine (PT). The turbine could not be manually rotated.

2.5.2 Disassembly Examination

From April 28-30, 2021, representatives from the NTSB and Honeywell convened at Honeywell facilities in Phoenix, AZ to disassemble and examine the engine. The engine was removed from its shipping container and placed onto a maintenance stand for disassembly. Externally the engine did not exhibit any signs of thermal distress or uncontainment.

Looking through the inlet, debris had been ingested into the engine and all the variable inlet guide vanes (IGV) appeared to be present and exhibited some impact damage (**Figures 28 and 29**). Looking through the exhaust diffuser, the exhaust thermocouple probes, the stage 2 PT rotor as well as the trailing edges (TE) of the stage 2 PT nozzle vanes were visible. All of the stage 2 PT blades were present, intact, and appeared undamaged, all six thermocouple probes were present, full length, and appeared undamaged, and the suction side of the stage 2 PT nozzle airfoils were covered in metal spray. Reaching through the exhaust diffuser, the N2 rotor system (PT-to-reduction gearbox-to-output shaft) would not rotate by hand. With the starter already removed, continuity was confirmed between the accessory drive gearbox and the compressor; a drive wrench was used to rotate the accessory drive gearbox and the compressor was seen rotating along with it.

Figure 28. Debris observed within the inlet.

Figure 29. Damage observed on the variable inlet guide vanes.

The output reduction carrier was removed and the output reduction gear carrier and the No. 1 bearing/bevel gear accessory gearbox drive compartment was oil wetted, no debris was observed, and the planetary gear assembly rotated freely and smoothly by hand. The planetary gears were in good condition and no visible signs or rotational damage noted. Another attempted was made to rotate the N2 rotor system with the output reduction gear removed and the sun gear power shaft still installed; the N2 rotor system still would not rotate by hand. The sun gear power shaft appeared in good condition and no anomalies were noted to the splines or helical gear teeth.

A magnetic chip detector is installed in the lower right side of the accessory drive gearbox and provides an indication of the presence of ferrous particles in the engine lubrication system. The magnetic chip detector was removed and no ferrous material was found on the tip. The oil filter housing, which is bolted to the accessory drive gearbox, has a reddish button pop-out button on the impending bypass valve to indicate higher than normal differential pressure. The red pop-out button was not extended. The oil filter, which is a cleanable and reusable 40 micron metal wafer disc filter element type, was removed from the filter housing; no particles were found on the mesh screen.

The PT assembly was separated from the combustor turbine assembly, which houses the stage 1 PT nozzle, stage 1 PT rotor, stage 2 PT nozzle, stage 2 PT rotor, and the external annular combustion chamber exposing the aft side of the stage 2 gas producer (GP) rotor and the front side of the PT stage 1 nozzle.

The stage 1 PT nozzle airfoils were present and were covered with material spray; no thermal distress was noted. The inner and outer combustion liners, as well as the annular plate that contains the conical swirl cups (22 of them) were intact and did not exhibit any burn-throughs, thermal erosion, or signs of hot streaks; however, considerable amount of blackening and coke-like/carbon build-up was observed. There are two fuel manifolds, a right and left manifold which are interchangeable and have dual-flow channel with 11 dual-orifice atomizers (fuel nozzles); all the atomizers were covered in black coke-like/carbon build-up.

With the stage 1 PT nozzle assembly removed, the PT rotor still could not be rotated by hand; however, while untorquing the locking plate bolts, the PT rotor rotated by hand but not smoothly and scaping sounds coming from the stage 2 PT blades could be heard. All the stage 1 PT rotor blades were present, full length, and were covered with metal spray; silver debris was found around the outside of the rotor. The outer diameter (OD) of the stage 1 PT blades did not exhibit a significant amount of circumferential scoring.

With the stage 1 PT rotor removed, the PT rotor was turned by hand again with some difficulty and scraping sounds could be heard. The stage 2 PT nozzle assembly was removed; all the airfoils were present and covered with metal spray. The stage 2 PT rotated smoothly and freely by hand after the stag 2 PT nozzle assembly was removed. Examination of the stage 2 PT blade running in the stage 2 PT nozzle assembly did not reveal any significant circumferential scoring marks or gouging from contact with the stage 2 PT blade shrouds; the two knife edges seals were still present. The stage 2 PT blade tips did not exhibit any significant circumferential scoring marks or gouging from contact with the stage 2 nozzle. No visible evidence of rotational scoring due to axial movement of the PT rotors.

No. 4 ball bearing was oil wetted, clean with no debris and the balls appeared to be undamaged, and the bearing rotated freely by hand; the cage appeared in good condition as well.

The stage 2 GP blades were all present, full length, and covered in metal spray. The PT shaft was able to be rotated by hand. All the stage 2 GP nozzle airfoils were present and covered in metal spray. Light metallic debris with a yellowish/light brown color similar to the material debris found in the inlet was observed in the outer curl of the combustion chamber; the outer and inner curl appeared in good condition with no burn-throughs or hot spots. The N1 rotor group (compressor-GP) was not disassembled any further.

The PT stage 2 rotor disk, P/N 1-140-272-04 and S/N 971365104097, was measured for growth. The print dimension for the bore diameter is 1.188 to 1.186-inches; the bore measured 1.1875-inches (**diameter 'A' in Figure 30**). The print dimension for the snap diameter is 4.980 to 4.982-inches; the snap diameter measured 4.980-inches (**diameter 'B' in Figure 30**). Additional measurements of the PT stage 2 rotor airfoils showed no significant permanent strain was present in the airfoil.

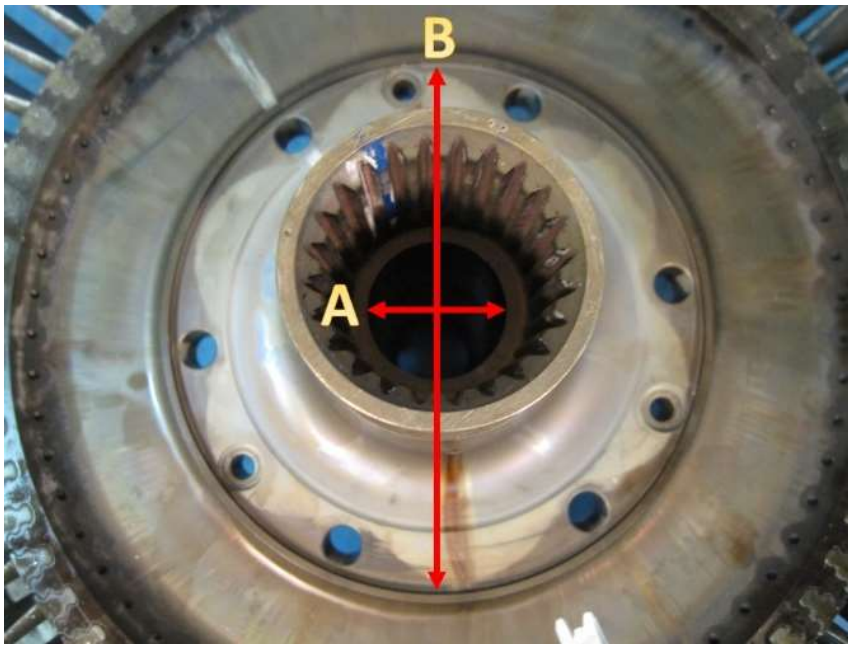

Figure 30. Stage 2 PT disk growth measurements.

3.0 Maintenance

The accident helicopter was maintained under the manufacturer's approved airworthiness inspection program (AAIP). According to the KMM, periodic inspections to be accomplished on the K-1200 include a preflight[6], a 100-hour/annual, 110-hour, 300-hour, 600-hour, 1025-hour, 1200-hour, 2500-hour, and 4000-hour inspection. A progressive inspection cycle, which can be used in lieu of the 100-hour/annual inspection, divides the helicopter into four inspection zones designated one through four. Each zone is inspected every 25 hours and a cycle is complete when all four zones have been inspected. Each zone inspection should be completed within five hours of its designated interval, but if one zone exceeds its designated interval, the remaining zones must be inspected at their original time intervals. All four zone inspections must be accomplished every 100 flight hours or 12 calendar months, whichever occurs first.

[6] The preflight inspection is to be accomplished prior to the first flight of the day.

Recurring inspections specific to the rotor blade servo flaps in the KMM include the following:

Interval	Inspection
Preflight	Visual inspection of the servo flap for cracks, nicks, scratches, dents, delaminations, and punctures; inboard, outboard, and flap horn bearings for excessive play, binding, corrosion, and security.
100-hour/Annual or Progressive – Zone One	Removal of the servo flaps for inspection of their brackets, control rod and clevis, and flap rod for nicks, scratches, erosion, pitting, corrosion, and security. This is followed by cleaning and inspection of the servo flaps and their attaching hardware and subsequent reinstallation of the servo flap.

A review of the accident helicopter's maintenance logbook found the helicopter was maintained under the progressive inspection cycle. There were instances in the maintenance logbook of a 100-hour/annual inspection, encompassing zones one through four, was accomplished during a single inspection sign off. On the operator's daily logsheets, a box included a list of items to be accomplished, with a space next to each item for a pilot/mechanic to sign off via initials. One of these items was the preflight inspection. A review of the daily logsheets from July 27, 2020 to August 23, 2020, encompassing about 79 flight hours, found no open discrepancies or anomalous trends. **Table 1** shows recent 100-hour/annual and progressive inspections performed on the accident helicopter.

Table 1. Recent 100-hour/annual and progressive inspections performed on the accident helicopter.

Date	ATT	Inspection
August 22, 2020	5,177.7 hours	Progressive – Zone Three
August 18, 2020	5,153.7 hours	Progressive – Zone Two
February 25, 2020	5,100.1 hours	100-hour/Annual
February 25, 2020	5,100.1 hours	Progressive – Zone Four[7]
September 9, 2019	5,076.7 hours	Progressive – Zone Three
September 2, 2019	5,050.0 hours	Progressive – Zone Two
August 7, 2019	5,027.2 hours	Progressive – Zone One
August 4, 2019	4,997.6 hours	Progressive – Zone Four

Attachment 1 of this report contains the logbook entries for the inspections accomplished in **Table 1**.

[7] Two separate entries for February 25, 2020 were found, one stating accomplishment of the Progressive Zone Four inspection and the other stating accomplishment of the 100-hour/Annual inspection.

4.0 Past Servo Flap Separations

Kaman received a report in April 2009 involving the accident helicopter[8] in which the servo flap of the left rotor system 'white' blade (S/N 401A) had completely separated from both servo flap brackets (**Figure 31**).[9] It was reported that when the pilot began to apply collective for a lift, he heard a repetitive "banging" sound, the helicopter began yawing to the left with full right pedal applied, and there was a vertical bounce. The pilot was able to land the helicopter. The left rotor system blades had a CTT of about 1,132 hours at the time of this event.

Figure 31. A separated servo flap from N361KA that was reported to Kaman.

On June 16, 2010, about 1440 mountain daylight time, a Kaman K-1200 helicopter, N134WC, impacted terrain about 5 miles west of Donnelly, Idaho.[10] The helicopter was conducting a 14 *CFR* Part 133 external load operation, and according to four ground witnesses, the helicopter had begun lifting a log off of the ground when they heard a very loud noise and saw pieces of rotor blade separate, followed by a separation of the fuselage and subsequent ground impact. Examination of the wreckage found the servo flap afterbody for left rotor system 'white' blade (S/N 169A) had fractured and separated from its spar. The upper and lower fractures on the

[8] According to the Kaman field service report, the helicopter registration at the time was N361KA.

[9] A search of the NTSB investigation database found no record of this event.

[10] The NTSB conducted an accident investigation of N134WC under case No. WPR10FA295.

servo flap afterbody were in the spanwise direction. In this accident, the left transmission pylon separated from the main transmission center housing and the right transmission pylon remained installed. The blades of the left and right rotor systems exhibited damage due to impact between the two rotor systems. The left rotor system blades had a CTT of about 9,633.2 hours at the time of the accident. **Figures 32 and 33** show images of the four rotor blades, with the left rotor system blades having S/Ns 169A and 169B and the right rotor system blades having S/Ns 94A and 94B.

Figure 32. Rotor blade S/Ns 94A (left) and 169A (right)

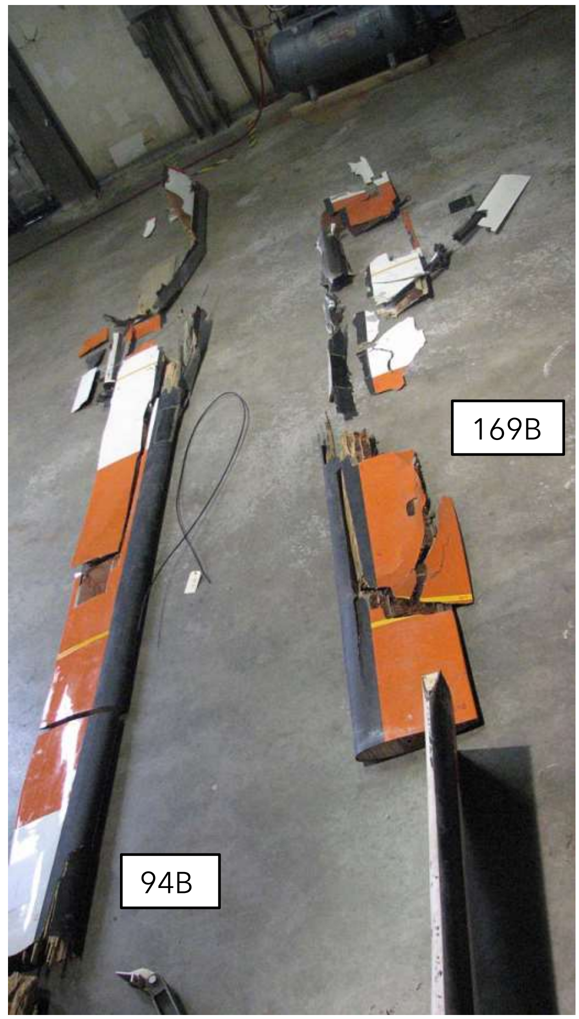

Figure 32. Rotor blade S/Ns 94B (left) and 169B (right)

[redacted]

[redacted]

APPENDIX A

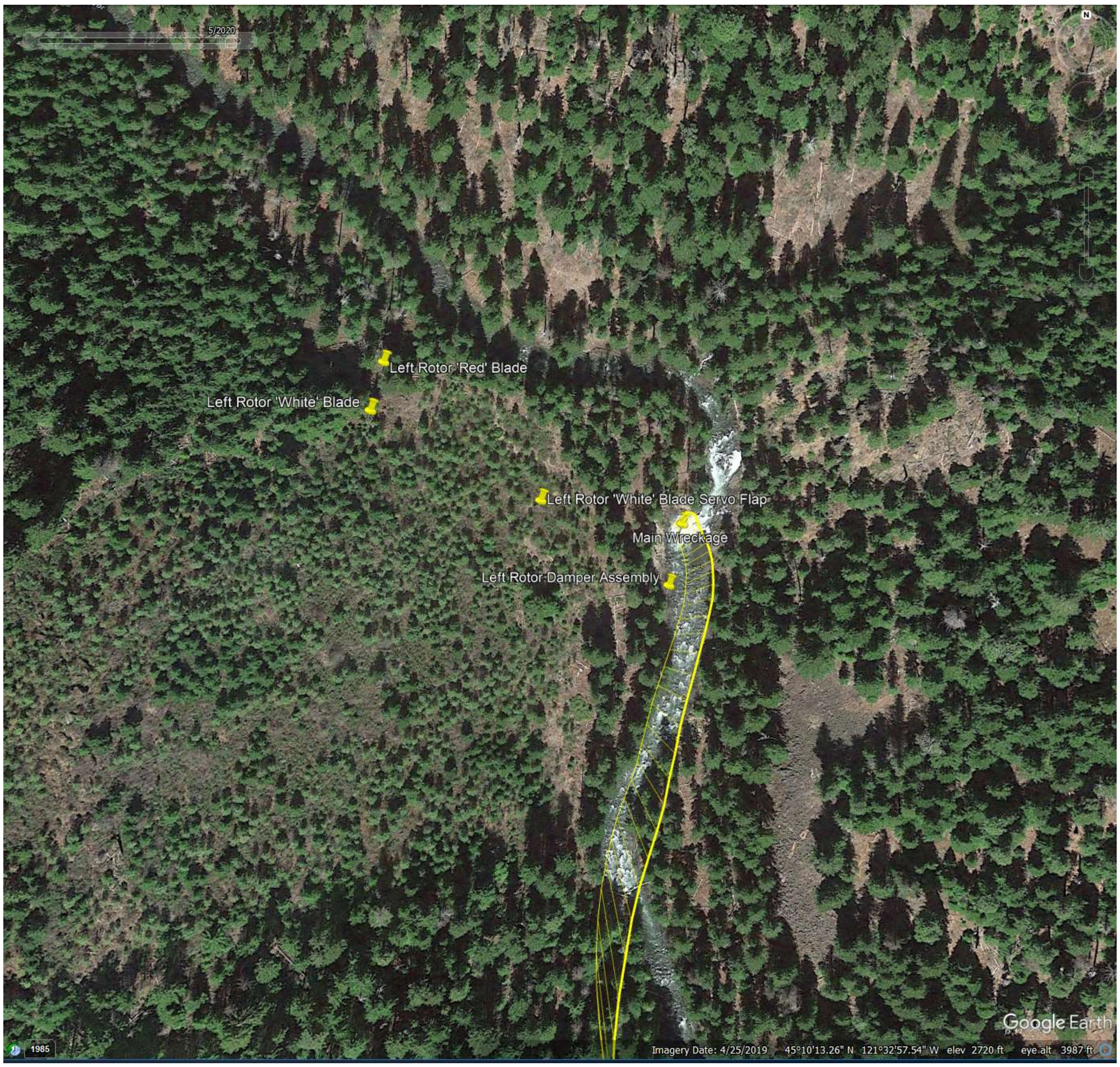

Figure A-1. The flight path (yellow line) and the approximate locations of various left rotor system pieces found around the accident site.

Figure A-2. A view of the flight path leading to the accident site (left) and a photo from the accident site in a similar direction to show the surrounding trees (right). (Image on the right provided by Central Copters.)

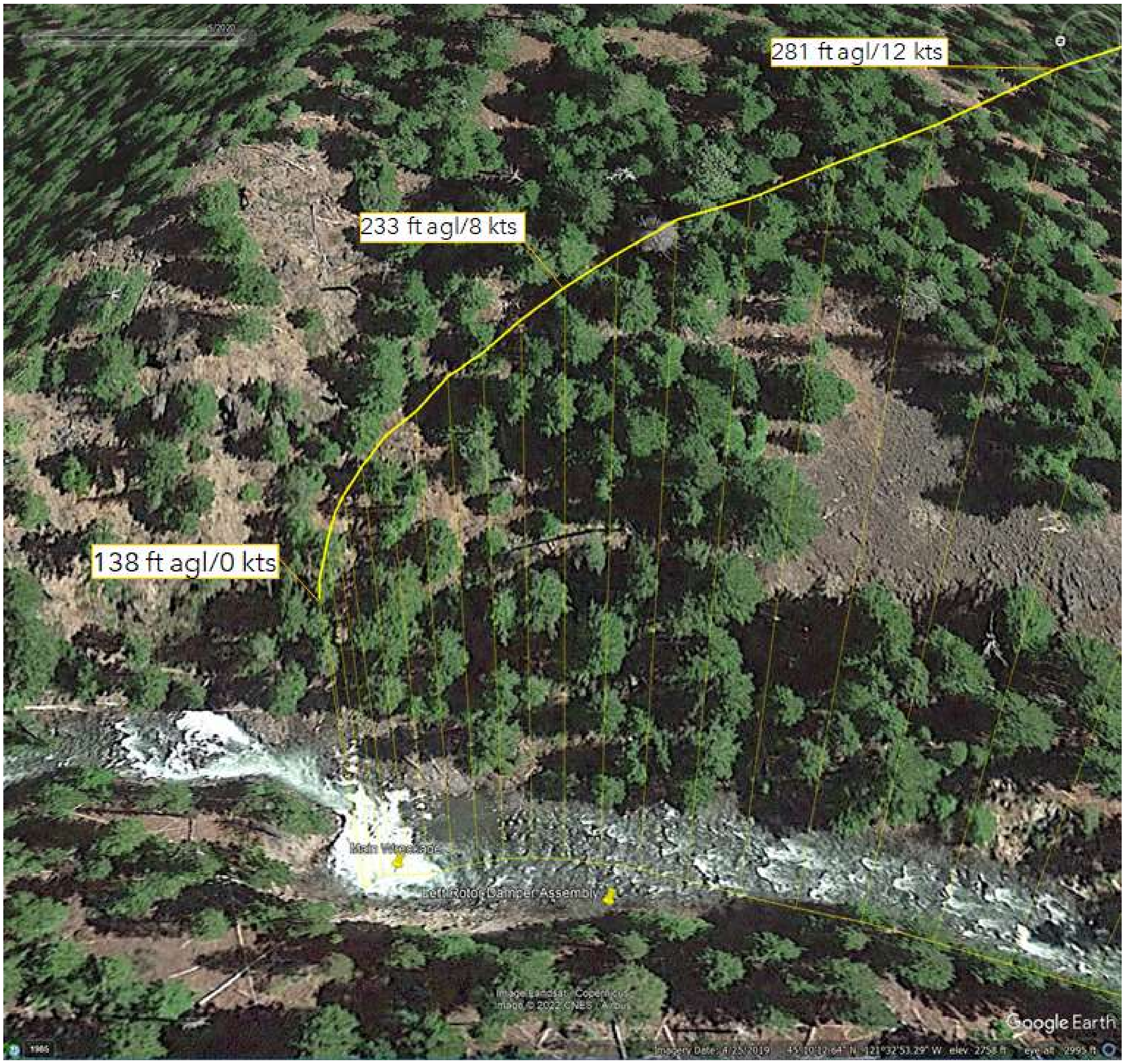

Figure A-3. The flight path showing height above ground and speed. The spacing of each vertical line of the flight path represents a 1-second interval.

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